Coastal Benthic Optical Properties (CoBOP): Optical Properties of Benthic Marine Organisms and Substrates

Charles H. Mazel
Physical Sciences Inc.
20 New England Business Center
Andover, MA 01810
phone: (978) 689-0003 fax: (978) 689-3232 email: mazel@psicorp.com
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LONG-TERM GOAL

The long-term goal of this research is to gain an understanding of the nature and significance of fluorescence and reflectance characteristics of benthic marine organisms in general, and coral reef cnidarians in particular. We wish to determine both how biological processes act to determine the optical properties and how optical measurements can be used to provide insight into biological state or process.

SCIENTIFIC/TECHNICAL OBJECTIVES

There were several objectives for this year's work:

- Make *in situ* measurements of fluorescence and reflectance spectra of benthic marine organisms and substrates in support of our own research and that of collaborators in the Coastal Benthic Optical Properties (CoBOP) research program;
- Conduct ground truth for the Fluorescence Imaging Laser Line Scanner: species identification of targets, video documentation, and measurements of fluorescence emission spectra
- Identify the substances responsible for the striking non-chlorophyll fluorescence responses in many corals;
- Measure the fluorescence efficiency of the pigments in selected specimens;
- Continue to analyze data collected during past field trips.

APPROACH

This work is part of the Coastal Benthic Optical Properties (CoBOP) program. The main effort in FY98 was conducted as part of the first large-scale CoBOP field campaign at the Caribbean Marine Research Center, Lee Stocking Island, Bahamas. The work described here was carried out by Charles Mazel (Physical Sciences Inc.) and Eran Fux (doctoral candidate, Department of Ocean Engineering, MIT).

In situ measurements of fluorescence and reflectance were made with the Benthic SpectroFluorometer (BSF)[1], a diver-operated instrument for measurement of spectral signatures from discrete benthic features. Laboratory measurements of fluorescence excitation and emission spectra were made with a FluoroMax-2 spectrofluorometer. Site documentation was done by visual inspection and videotape recording.

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Two laboratory approaches were taken to determine fluorescence efficiency. We are not concerned here with the classical definition of fluorescence quantum efficiency (photons fluoresced / photons absorbed), but rather a 'practical' efficiency that relates the photons fluoresced to the available incident photons (the spectral irradiance scaled by the excitation spectrum for the fluorescent pigment). One method used a narrow-band light source for illumination. The other used the results of the separation of the exitance into true reflectance and fluorescence components(see contract N000149710041), combined with measurements of the broadband incident light source and the pigment excitation spectrum.

Fluorescence microscopy, fluorescence microspectrofluorometry, measurements of excitation and emission spectra, and extraction of pigments for more detailed analysis were used to address the problem of identifying the pigments responsible for the coral fluorescence.

WORK COMPLETED

Participation in the 1998 CoBOP field campaign was successful. Measurements were made to address the stated objectives. Data and sample analysis are well advanced. Some has been reduced to final form, while the remainder has been examined for quality and completeness. Where appropriate, data have been forwarded to collaborating researchers.

RESULTS

The FILLS ground truth data are being organized in a Web-based format[2] that provides interactive access to species identifications, video images, and spectral data (figure 1).

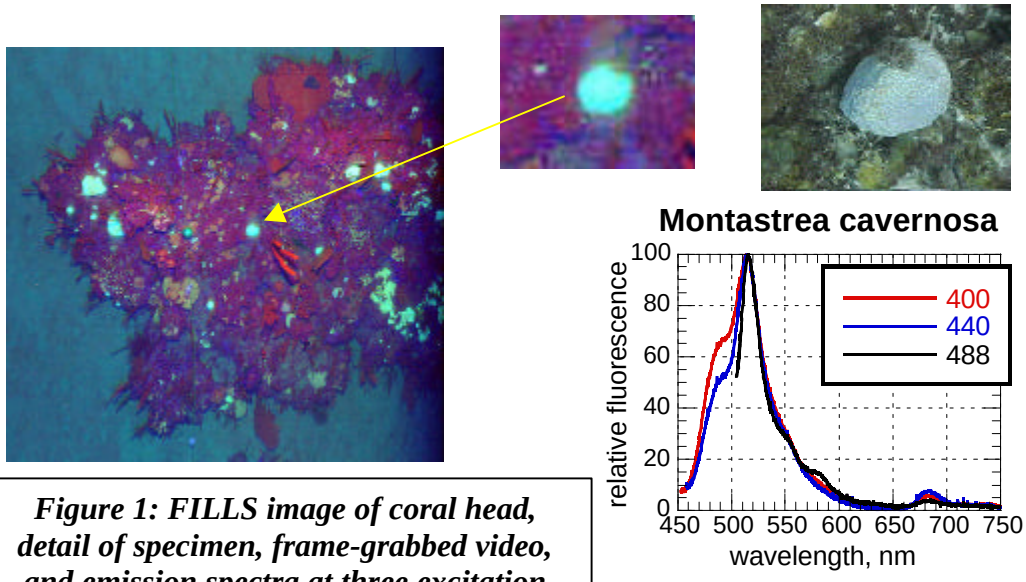

Figure 1: FILLS image of coral head, detail of specimen, frame-grabbed video, and emission spectra at three excitation wavelengths.

The two methods of computing fluorescence yield produced results that are similar but not always identical (figure 2, table 1). Multiple measurements from a single specimen were made using one of the methods, and in such cases the spread in the data indicated that there is either a reasonable amount of variation in the yield within a specimen or in the data collection process. The specimens selected for measurement were intensely fluorescent, and so the values should be taken as representing the upper range of values for fluorescent corals.

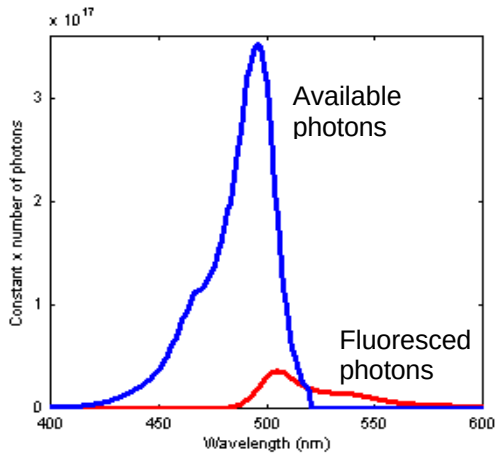

Figure 2. Data required for computation of effective fluorescence yield.

	Method 1	Method 2
515 pigment		
Agaricia sp.	3	
Colpophyllia natans	10.2	10.7
Montastrea cavernosa	4.7	
Montastrea faveolata	8.8	10.3
Mycetophyllia sp.	4.7	11.6
Scolymia sp.	6.0	11.3
Scolymia sp.	5.2	
Scolymia sp.	8.2	13.9
575 pigment		
Scolymia sp.	2.3	
Scolymia sp.	3.0	

Table 1. Computed values for effective fluorescence yield

IMPACT/APPLICATIONS

The measurements of benthic spectral properties will contribute to understanding of the implications of biology on optics. They will also assist in the effort to use optical remote sensing to probe benthic biological systems and will be used in radiative transfer modeling. The fluorescence emission measurements for FILLS targets will aid in the ongoing development and field application of this sensor system. The fluorescence yield measurements are of value for modeling of spectral signatures in remote sensing applications.

It is premature to report specifics here, but the preliminary identifications of several of the fluorescing substances in corals are extremely interesting and may have important implications for the study of coral biology.

TRANSITIONS

Spectral measurements of sediment reflectance are being used by members of the CoBOP sediment group as part of their work in correlating sediment properties and sediment optics. Reflectance data from various substrates are being used by Curt Mobley as endmembers for radiative transfer modeling with Hydrolight. Mike Strand and Bryan Coles will use the FILLS ground truth data as part of their ongoing work in development of the FILLS system and interpretation of its data. I have begun collaborating with Rob Wheatcroft in adapting his underwater photography system to use fluorescence to image the distribution of benthic microalgae.

RELATED PROJECTS

I am working on a new ONR project to develop an improved version of the BSF for more general use by CoBOP and other researchers. I will shortly be involved in a new project to develop calibrated fluorescence reference panels for use with the FILLS system.

REFERENCES

1 Mazel, C. H. "Diver-operated instrument for in situ measurement of spectral fluorescence and reflectance of benthic marine organisms and substrates", Opt. Eng. 36:2612-2617 (1997).
2 http://www.psicorp.com/mazel/research/cobop/lsi98/fills/npcoral.html